Does Human Capital Cause Growth in Latin America?

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Abstract

The importance of human capital in explanations of growth processes is crucial both in theoretical and empirical analyses. Nevertheless, the results obtained in empirical studies do not always show the expected positive relation, normally because the proxy used to measure human capital is not the most appropriate and because this variable is usually considered as an explanatory variable. This paper tries to deal with these two problems considering a sample of 18 Latin American countries for the period 1950-2000. To this end, a complex human capital index has been constructed and using the Granger-causality methodology. The paper shows how the causation between this variable and growth runs in both directions, even after taking the physical investment rate into consideration. Moreover, the paper confirms that investment in physical capital precedes human capital in the poorest countries of the region whereas the two types of investments operate together in the richest.

Resumo

A importância do capital humano nas explicações dos processos de crescimento é crucial tanto nas análises teóricas quanto nas empíricas. No entanto, os resultados obtidos em estudos empíricos nem sempre mostram a relação positiva esperada, normalmente porque o proxy utilizado para medir o capital humano não é o mais apropriado e porque esta variável é geralmente considerada como uma variável explicativa. Este artigo procura abordar esses dois problemas considerando uma amostra de dezoito países da América Latina para o período 1950-2000. Para tanto, foi construído um complexo índice de capital humano e usando a metodologia Granger-causality. O artigo mostra como a causalidade entre essa variável e o crescimento ocorre em ambas as direções, mesmo considerando a taxa de investimento físico. Além disso, o documento confirma que o investimento em capital físico precede o capital humano nos países mais pobres da região, ao passo que opera em conjunto com o investimento nos mais ricos.

INTRODUCTION

The importance of human capital in explanations of growth and convergence processes has been crucial since the proposals put forward by Schultz (1961), Becker (1962) and Abramovitz (1986) among others. Since then it has been one of the main additional variables included in this kind of analysis[1]. In the empirical field, many papers have attempted to test the implications of economic growth theories and to determine the main sources of growth, placing special emphasis on human capital as a determinant, using cross-section data for a large sample of countries. However, the results obtained do not always show a positive relation between human capital and growth, especially if the sample under consideration consists of a set of developing countries.

The first of the two main causes of this situation concerns the way in which the concept of human capital is captured. Normally, this concept is approximated by school enrolment rates ahead of other important factors. The second problem is that human capital is considered as an explanatory variable, both in theoretical and empirical approaches.

This paper tries to deal with these problems using the Latin American region as a sample of studying, a set of countries that have been studied in some analyses without reaching a clear conclusion about the impact of human capital on growth in spite of the fact that the rise in the average educational level of the population in the post-war period had a crucial effect on the quality of labour[2]. Hofman (2000), for example, maintains that the average number of years of formal education of the population is the best proxy available for human capital improvements and highlights the importance of education as a form of investment which increases workers' productivity and favours growth in the three decades after World War II. It does not, however, allow us to draw general conclusions as it only considers nine of the region's countries and fails to test the hypothesis empirically. In the same line, De Gregorio (1992) analysed twelve Latin American countries during the period 1950-1985 and reached the conclusion that human capital, measured by literacy rates, had a positive effect on growth but, paradoxically, school enrolment (primary and secondary school) indices did not have a positive relationship with growth[3]. One possible reason for these contradictory results may be that the measure used for human capital is inappropriate.

Given the scarcity of studies of this type in Latin America and the fact that those which do exist are not wholly convincing, this paper will make a modest attempt to fill this gap by taking a group of 18 countries as a sample during the period 1950-2000.

To deal with the first task, a compact index of human capital is constructed using the principal components technique and considering some additional variables as well as primary and secondary schooling such us the dependency rate, health, life expectancy and infant mortality.

Moreover, this paper addresses the issue of causality in the relationship between the concept of human capital and long run economic growth in the Latin American region. It is shown that existing empirical studies of these kinds of relationships provide evidence of correlation rather than causation. The paper attempts to fill this gap using the Granger causality test of human capital vs. growth using aggregate measures of

1 See Shultz (1960), Denison (1985), Romer (1989), Barro (1991) and Mankiw, Romer and Weil (1992) for pioneering empirical studies in this field in which human capital plays an important part in the explanation of growth and convergence.
2 Hofman (2000, 21).
3 De Gregorio (1992, 61).

human capital.

The results obtained tell us that the causation runs in both directions, that is human capital is crucial for explaining economic growth and vice versa and these relationships remain robust once the investment in physical capital, the other important variable that explains growth, is taken into account. Moreover, splitting the sample into two parts, the richest and the poorest countries of the region, the results obtained, in consonance with other studies, show how investment in physical capital represents a fundamental link between growth and human capital. This variable precedes human capital accumulation in the poorest countries, acting as a necessary condition, and operates together with human capital in the richest sample when explaining growth.

2.- THE HUMAN CAPITAL CONCEPT:

As has been made clear in the section which reviews the studies focusing on Latin America, the human capital variable was normally calculated using primary and secondary schooling between the ages of 15 and 64. We have seen that the results thrown up by this variable for the various samples of Latin American countries included in these studies are not always as robust as would be hoped. This leads us to doubt the appropriateness of the measures of formal education used to estimate the concept of human capital.

Unlike the situation in other studies of the Latin American region, in this paper human capital will take into account other factors as well as enrolment rates in primary and secondary education as a proxy. This figure alone could be inaccurate as we would also require information regarding failure rates, the percentage of pupils who successfully completed their studies and an indicator of educational quality, among other factors[4]. In fact, the concept of human capital is broad and includes other elements[5]. It has long been argued that human capital is a complex input that consists of more than knowledge capital and, in particular, that attention should to be paid to health capital, nutrition and the professional experience of the workforce[6]. If these ingredients are important aspects of human capital their omission will result in a model with misspecification when, for example, we try to quantify the contribution of human capital to economic growth from an empirical point of view.

This is why additional variables have been included in an attempt to provide more reliable results for human capital. These extra variables are infant mortality and the number of inhabitants per doctor, life expectancy and the dependency rate. The latter is defined as the percentage of the population under the age of 15 or over the age of 64 compared with those between the ages of 15 and 64.

The aforementioned variables have been seen, in one way or another, as components of human capital in diverse empirical studies and, especially, in theoretical studies based on Ram and Schultz's (1979) pioneering global proposal. Their analysis, which focuses on low-income countries and more particularly on the case of India, highlights the importance that an increase in life expectancy, as a consequence of an improvement in health, has on the accumulation of human capital and, by extension, on economic growth. The study puts forward the following argument: an improvement in health leads to a decrease in the mortality rate and an increase in life expectancy. At first, there is a small decrease in

4 See Barro and Lee (1993, 2000), De la Fuente and Doménech (2000) and Barro (2001) for studies in which attempts are made to estimate human capital more accurately using measures of educational attainment, quality and quantity of education.
5 See Becker (1962) for a broad definition of the concept of human capital.
6 See, for example Schultz (1961), Mushkin (1962), Knowles and Owen (1995) and Sen (1998).

the fertility rate which allows a spurt in population growth, setting off a demographic transition which, in the end, will lead to a larger increase in the working population than that experienced by the dependent population.

The study also shows that an increase in life expectancy leads to a rise in the incentives to receive more formal education and improved health. For that reason, the stock of human capital in the form of better health and more schooling becomes larger and enhances the quality of labour.

So, they conclude that one important channel through which demographic trends affect growth is obviously the size and the quality of labour forces.

Within this context, later theoretical studies such as that of Barro and Sala-i-Martín (1995) stress the importance of life expectancy. These authors think that life expectancy has a strong, positive relation with growth as it proxies features reflecting human capital. They show that when life expectancy is short, the depreciation rate of human capital is high, making its accumulation more difficult and vice versa. Due to the fact that human capital is an important driving force of growth, we would expect the growth rate to depend on life expectancy.

This variable is also seen, in a theoretical model by De la Croix and Licandro (1999), as one of the factors explaining growth via its effects on the accumulation of human capital. They show that life expectancy is positively correlated with human capital because favourable shifts in survival probabilities always induce longer schooling and later retirement. Nevertheless, they point out that the effect of life expectancy on growth is positive for economies with a relatively low life expectancy, but could be negative in more advanced economies. This would be possible in some cases because the positive effect of longer life on growth could be offset by an increase in the average age of the working population.

Similar results are to be found in Boucekkine, De la Croix and Licandro (2002). Their study includes additional variables in order to reflect the effects of the main demographic parameters on the accumulation of human capital and economic growth. These authors show that, theoretically, if in addition to taking life expectancy into account, the mortality and fertility rates are also considered, more ambitious conclusions can be reached.

For these authors, the way longevity increases is important: improvements in longevity have different effects depending on whether the reduction in death rates affects young or old agents. So, for these authors there is a “growth-maximizing” fertility rate, implying an adequate percentage of students and pensioners.

Mortality and fertility rates are two of the variables given serious consideration in this type of theoretical study. For example, Kalemli-Ozcan et al. (2000) present analytic results demonstrating that a decline in mortality produces economically significant increases in schooling and thus in the level of human capital.

The relationship between fertility and human capital investment and its implication for economic growth, focusing on the effects of declining mortality, is also considered by Kalemli-Ozcan (2002). He shows how lower mortality encourages educational investment in children and leads parents to have fewer children. Thus we can observe a quality-quantity trade-off in the demand for children. This result supports the earlier proposals put forward by Rosenzweig

(1990) and Becker, Murphy and Tamura (1990). The former shows that fertility has a direct influence on human capital. Fertility and mortality may be positively correlated because parents living in unhealthy environments are more aware that their children might die. Consequently, they invest less in each child and bear more children which reduces the human capital level of the economy[7]. Becker, Murphy and Tamura (1990), in the second of the aforementioned studies, move in the opposite direction taking the fertility rate as an endogenous variable which depends on the abundance or scarcity of human capital existent in a given society and show that societies with abundant human capital invest more in each child and have small families and vice versa.

On the other hand, the level of health enjoyed by workers as a form of human capital is considered, at a theoretical level, in a pioneering study by Grossman (1972) as an element leading to an increase in the productivity of the workforce.

Similarly, Knowles and Owen (1995) also emphasized the "health capital" component of human capital, taking life expectancy as a proxy for the stock of health capital and considering the former variable as an indicator more directly relevant to the production of output. The introduction of this proxy in Makiw, Romer and Weil's model (1992) gives results which suggest a stronger and more robust relationship between income per capita and health capital than between income per capita and educational capital. In particular, for the less developed sub-sample they demonstrate empirically that health capital is significant whereas educational capital is not[8].

Bloom and Canning (2000), following a similar line of argument to that of Ram and Schultz (1979) but extending it to embrace a broader sample of countries, look at the way in which healthier populations tend to have higher labour productivity. Healthier people tend to have more education because people who live longer have stronger incentives to invest in developing their skill and good health also promotes school attendance and enhances cognitive functions. These authors also show how health has an indirect effect on an economy's level of human capital and on its rate of growth via a transitional demographic effect which would lead to a faster growth in the workforce than in the dependent part of the population. Such an economy would then enjoy an increased global level of human capital and would be capable of more rapid growth. The opposite situation would result from more rapid growth of the dependent population than that experienced by the workforce. This situation is clearly logical if we consider that old non workers as part of the dependent population represent part of the total human capital which is withdrawn from the productive process. On the other hand, young non workers included in the dependent part of the population do not represent human capital for the economy.

We see, then, that in all previous studies, life expectancy, health, mortality and fertility rates are the factors which explain the level of human capital as estimated by schooling which would appear to act as a dependent variable in all cases. We have also observed that all these variables display high levels of correlation, to the extent that they are often used as proxies of each other, life expectancy and health or mortality and fertility being examples.

The objective of this article is to bring together all these ideas and variables, without the intention of explicitly analyzing internal causality, in order to create a compact global index of human capital for the sample of Latin American countries under observation. To this end, other

7 Rosenzweig (1990, 58).
8 Knowles and Owen (1995, 105).

variables in addition to primary and secondary schooling rates will be taken into account. The number of inhabitants per doctor will be considered as a measure of the level of health care, a measure which could act as a proxy for health capital. Moreover, we take into account the infant mortality rate as a proxy for fertility and, finally, the dependency rate, which is considered in order to reflect the possible effect of the demographic transition on the process of accumulation of human capital.

4.- THE HUMAN CAPITAL INDEX:

4.1. The sample:

The sample consists of 18 countries of the region for which the necessary information for the period 1950-2000 is available. This period has been divided into sub-periods of five years in line with the statistical information which is usually published for a benchmark of five years.

A list of the countries analyzed and information regarding the sources used can be found in the appendix. Two different sub-samples were considered: the richest countries and the poorest countries.

The variables which make up this index are enrolment rates in primary and secondary education (PRIM and SEC respectively), the infant mortality rate (MORINF), the number of inhabitants per doctor (SAN), life expectancy (ESP) and the dependency rate (DEP). It should be highlighted that all these variables are considered at the beginning of each of the five-year sub-periods identified. The results provided by the index, logically, will refer to the level of human capital at the beginning of each of these sub-periods.

4.2.- The construction of the human capital index:

Given that, as previously noted, the level of correlation between this set of variables is very high, it will be necessary, when constructing the human capital index (HCI), to deal with the problem of multicolinearity present in the data. The construction of this index for the particular case of Latin America will be one of the main tasks of this paper. The index will subsequently be applied to a growth model in order to test its ability to explain the growth process in the region.

Once the components of the index have been selected, the next problem is to decide how to incorporate them. Unfortunately, economic theory does not specify a model for the construction of indices of human capital and, consequently, the principal components method is frequently used in this type of study. Principal component analysis assigns weights on the basis of the distributions and interrelations between the various components.

This methodology, however, is not perfect and has been the object of varied criticism. Some critics are of the opinion that it fails to reflect a conceptual link between the theory behind the selection of elements and the index itself. Others observe that the results are sensitive to the scale of measurement of the different variables under consideration and highlight the ambiguity involved in the interpretation of the results. Finally, it is argued that this methodology assigns lower weights to variables which are highly correlated with others[9].

This article, however, while acknowledging the problems involved with the proposed method, uses factorial analysis based on the prin-

9 Heckelman and Stroup (2005).

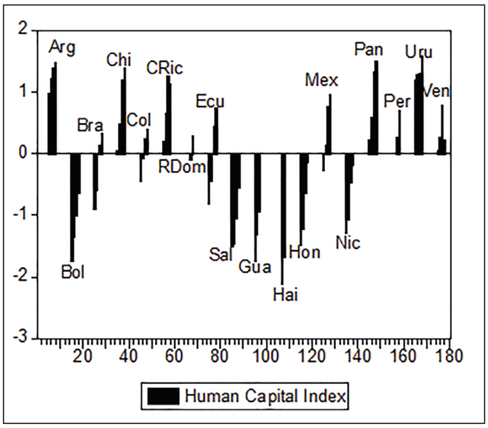
cipal components method to construct the HCI in the belief that these problems are minimal in this particular case. On the one hand, and as has previously been mentioned, there is no underlying economic theory which deals with the calculation of an index of human capital and, therefore, principal components analysis cannot contradict such a theory. On the other hand, the variables have been standardized with the object of minimizing the problem of sensitivity to the scale of measurement. Finally, the last of the aforementioned criticisms, which referred to problems caused by high levels of correlation between the variables, is also minimized by considering the correlation matrix. An observation of this matrix shows that the correlations are high enough to justify the use of principal component methodology but not high enough to cause this problem (see Table A.1 in the Appendix).

The results obtained from the application of the methodology described are presented in Table A.4. In such cases it is better to consider a linear combination of co-related variables in order to avoid possible biases in the individual estimates of the values caused by the multicolinearity problems present in the data.

The signs adopted by the variables in the first component, on which the global index is based, are coherent. Enrolment rates in primary and secondary education and life expectancy have positive signs while infant mortality, number of inhabitants per doctor and the dependency rate are negative (Table A.4). This first component explains 67.5% of the variance (see Table A.3), a percentage considered sufficient given that although the inclusion of a second component would lead to a proportional increase in this figure, it would also make the interpretation of the results more difficult. What is more, as can be seen from the analysis, all the variables have a greater weight in this component which prompts us to consider only a linear combination of variables in which their respective weightings are provided by the values indicated in this first component. The fact that only the first eigenvalue is greater than one justifies this decision.

The graph representing the different levels of human capital obtained for each country is shown below:

Graph 1: Index of human capital:



As can be seen in Graph 3 some rich countries, such as Argentina, Chile, Mexico, Uruguay and Venezuela, present high levels in the index of human capital. Brazil is an example of a country which has become wealthy and

Table 1: Annual average growth rate, 1951-2000:

Country	(%)	Country	(%)
Argentina	0.47	Guatemala	0.52
Bolivia	0.01	Haiti	0.12
Brazil	1.27	Honduras	0.11
Chile	0.96	Mexico	0.93
Colombia	0.77	Nicaragua	-0.15
Costa Rica	0.75	Panama	0.98
Domin Rep.	1.26	Peru	0.53
Ecuador	0.66	Uruguay	0.52
El Salvador	0.39	Venezuela	0.07

Note: the calculation for the Dominican Republic starts in 1952 and the growth rate for Haiti corresponds to the period 1968-1998 has experienced a reasonable level of human capital in recent years. But, at the same time, we can observe other poorer countries with a considerable value for the later period. These are the Dominican Republic, Ecuador, Panama and Peru. In line with the theory, this last group of countries would have higher possibilities of growth (and convergence). In fact, with the exception of Peru, they are among the poor countries with higher rates of growth, as we can see in Table 1.

There is a fairly high degree of correlation between the growth rates and the level of human capital, at least among the poor countries. This fact suggests that human capital is one of the forces behind the growth process in the region.

Table 2: Explaining the growth process in Latin America: All the countries

Exogenous	(1)	(2)	(3)
Constant	0.014 (1.831)	0.014 (1.831)	0.027 (1.127)
Initial GDP per head	-0.003 (-1.252)	-0.003 (-1.252)	-0.021 (-3.594)
Investment rate	0.025 (3.143)	0.025 (3.143)	0.046 (2.909)
Active population growth	0.018 (1.719)	0.018 (1.719)	0.0048 (0.270)
Human capital index		0.003 (2.718)	
Primary enrolment			-0.008 (-1.242)
Secondary enrolment			-0.009 (-1.314)
Infant mortality rate			0.008 (1.801)
Inhabitants per doctor			-0.0008 (-2.402)
Life expectancy			0.085 (3.112)
Dependency rate			0.004 (0.717)
DUM	-0.011 (-9.992)	-0.014 (-10.302)	-0.012 (-11.026)
Weighted statistics	Nº Obs=175 R-sq.=0.397 D-W=1.939 F=29.653	Nº Obs=65 R-sq.=0.728 D-W=1.602 F=35.375	Nº Obs=91 R-sq.=0.545 D-W=1.697 F=11.784

Dependent variable: GDP per head growth
Method: GLS (cross section weights)

The human capital variable is calculated in this way and included in the typical Solow growth model in Table 2. Given that the index, due to its design, reflects the level of human capital at the beginning of each of the five-year sub-periods identified in the sample, it enters the model with a lag of five years. In other words, the explanation of growth for the sub-period 1950-1955 is based on the level of human capital of 1950 and so on.

This leads to a positive value indicating that those countries in the sample with the highest levels of human capital – in other words, highest rates of schooling and life expectancy and lowest rates of infant mortality and dependency and lower numbers of inhabitants per doctor – have a greater possibility of growth, as we can see in the next table[10].

DUM is a dummy variable that tries to capture the differential rates of growth achieved by the region during the eighties (the "lost decade") [11] , and the initial GDP per head is the convergence term that indicates if those countries that started with a lower GDP per head level have been capable of growing faster than the richest thus closing the gap with them. For this to be the case, the sign of this variable must be negative and statistically significant.

As can be seen in estimate (1), the coefficient of the level of GDP per capita at the beginning of the period is negative but not significant. In both approaches the investment rate has a positive effect on growth, as Solow's model would predict, and its significance is unchanged

10 If the variables which make up the human capital index are considered in isolation when calculating an estimate, the results obtained are not coherent due to the bias caused by the presence of multicolinearity. Thus the variable which represents infant mortality has a positive value although it is not significant and the primary and secondary schooling rate variables are negative and, therefore, incorrect.
11 This is significant in every specification of the model.

throughout. The estimated value of the variable which represents the growth rate of the active population is positive. Despite the fact that this variable is considered instead of total population growth, it is impossible to draw any conclusions regarding the effect produced by this variable as its value is neither significant nor robust. Its sign changes with variations in the specification of the model as can be observed in successive estimates[12].

The lack of conditional convergence once the main steady state variables are considered suggests the possibility of introducing other additional and crucial variables in order to obtain a more accurate explanation of the process. Consequently, in equations (2) and (3) we have expanded the model introducing some variables relating to the human capital concept.

Effectively, from the information in this table (equation 2) we can say that those poor countries with a high level of human capital will be able, not only to grow faster, but to reduce the gap with the richest. This is because the initial GDP per head appears to be negative and significant just after the human capital index is introduced into the model. This result confirms the possibility of a conditional convergence process due to the fact that this kind of estimate is, by definition, a conditional inference in which we are assuming that every country reaches its particular steady state equilibrium.

All these outcomes are in line with Abramovitz (1986) who sustains that the possibilities for a country of reducing the distance with richer ones are higher when it is technologically backward but socially advanced, a concept compounded, among other factors, by the country's level of human capital. What is more, as has already been seen, human capital constitutes the key element which allows these countries to close the gap with the wealthiest nations of the region.

The wrong sign in variables such as primary and secondary enrolment, infant mortality rate and dependency rate in equation (3) from Table 2 and the insignificance of all variables except inhabitants per doctor would confirm the presence of a multicolinearity problem. For this reason is better to consider the HCI constructed before.

This finding could lead to the conclusion that human capital is one of the driving forces behind economic development in these countries. Nevertheless, the estimation of semi-reduced forms, in general, presents problems of endogeneity that are difficult to overcome. Also, some variables may be capturing spurious correlations rather than economic relationships.

In order to be more certain, however, its robustness will have to be investigated. In particular, we are interested in discovering whether the causation runs in the direction usually specified by the literature or whether the possibility of a double causation exists. The next section deals with this matter.

6.- CORRELATION VERSUS CAUSATION:

6.1. The Granger causality methodology

After resolving the problem of how to measure the concept of human capital, the second problem to solve is to test whether human capital is capable of explaining growth in the region.

When intermediate values of a particular variable (human capital) are regressed on another

12 Bloom and Williamson (1998) maintain that the inclusion of total population growth in the growth model leads to errors and that it is better to distinguish between working population and total population.

variable (growth) during a determinate period it is clear that little can be said regarding causality. Normally, these types of studies on growth clearly establish correlation, but not causation. The questions to be addressed now are whether human capital causes growth or vice versa, or whether the two concepts are endogenously determined. A very good approach to answering this type of question is the test of causality introduced by Granger (1969). The basic idea of Granger-causality is to test whether lagged values of a particular variable significantly affect the contemporaneous value of another variable. That is, we can say that growth causes human capital if growth precedes human capital and vice versa.

To this end, the following equations are created using least squares (LS):

$$\Delta GDPpc_t = \alpha_1 + \sum_{i=1}^{m} \alpha_{11}(i)\Delta GDPpc_{t-1} + \sum_{i=1}^{m} \alpha_{12}(i)HCI_{t-1} + \varepsilon_{\Delta GDPpc,t}$$
$$HCI_t = \alpha_2 + \sum_{i=1}^{m} \alpha_{21}(i)\Delta GDPpc_{t-1} + \sum_{i=1}^{m} \alpha_{22}(i)HCI_{t-1} + \varepsilon_{HCI,t}$$

Where ΔGDPpc are five-year averages of the growth rates of per capita GDP and HCI is the level of human capital at the beginning of these five-year sub-periods.

In this sense we can say that HCI does not cause DGDPpc in Granger's sense if all a_{12} (i)= 0. Similarly, DGDPpc will not cause HCI if all a_{21}(i)=0.

Thus, the Wald test applied in order to check the joint significance of the coefficients a_{12} (i)= 0 and a_{21} (i)=0 respectively, indicates that the null hypothesis which states that all these coefficients are zero can be rejected.

6.2. The empirics

Before developing the causality test, a reasonable first step in empirical analysis is to test the order of integration for the variables being used. In order to test Granger-causality between GDP per capita growth and human capital both two time series must be stationary. The panel unit root test results are presented in the next table and show how the tests reject the null hypothesis of non-stationarity for both variables. For what they are worth, at least these test results do not rule out proceeding to the Granger-causality analysis[13].

Table 3: Panel unit root test results (18 countries, 1950-2000)

H0: Unit root in level	GDPpc growth	Human Capital
Levin, Lin & Chu t	-8.979 -15.753	(0.0000) (0.0000)
ADF Fisher Chi-square	135.274 65.504	(0.0000) (0.0002)
PP Fisher Chi-square	138,271 67.008	(0.0000) (0.0001)

Since Granger-causality test results are sensitive to the choice of lag length m in the time-stationary VAR model given by Equation (1), it is important to specify the lag structure appropriately. To this end, the choice of the optimal lag length on the Schwarz Information Criterion (SIC) and the Akaike Criterion (AIC) is followed. Table 4 shows that after estimating Eq(1) with LS and based on this criterion the optimal lag length is two[14].

Table 4: Optimal lag length for Equation (1):

Lag	1	2	3
SIC	-5.933	-5.937	-5.779
AIC	-6.033	-6.133	-5.882

Table 5 reports the results of the Granger-causality test of economic growth rates vs. the levels of the human capital index. This paper found that the growth of human capital is not re-

13 Every model has been estimated introducing a dummy variable that captures the differential behaviour experimented by these economies during the decade of the '80s.
14 In this sense, the optimal lag length corresponds to the number with the lower value for the statistic SIC or AIC.

Table 5: Causality test between human capital and growth:

Summary index of human capital	HCI→GDPpc	→GDPpc→HCI	HCI→GDPpc (Investment as control variable1)	∆GDPpc→HCI (Investment as control variable
Whole sample1	F=20.861 Chi-squred=41.722	F=45.347 Chi-qured=90.695	F=9.152 Ch-qured=18.305	F=4.732 Ch-qured=9.464
The richest2	F=2.679 Chi-squred=41.722	F=0.178 Chi-qured=0.356	F=4.542 Ch-qured=9.084	F=1.501 Ch-qured=3.002
The poorest3	F=5.435 Chi-squred=10.871	F=3.987 Chi-qured=7.974	F=0.790 Ch-qured=1.580	F=0.997 Ch-qured=1.996

lated to the growth of output, contrary to what the Lucas (1988) model would lead us to expect but it is the level of human capital the variable in connection with growth, something in line with results found in other analyses such us Kyriacou (1992). This author offers two possible explanations for this finding. First, that the output elasticity of human capital is positively related to the human capital level. This is because a country cannot have a significant positive contribution of education to growth unless it has already attained a certain threshold level of human capital stock. A second explanation relates to an omitted variable of technological growth. In this case, it is possible to consider the initial level of human capital to be a proxy for technological growth, as in Romer (1990), so that the level of average human capital could be a proxy for the growth of technology[15].

We have carried out the analysis for the whole sample and distinguished between the richest and the poorest samples in order to specify more clearly whether the connection between human capital and growth depends on the level of development.

Considering the whole sample, the results obtained tell us that the causation runs in both directions; that is, human capital is crucial for explaining economic growth and, at the same time, growth is necessary to achieve a higher level of human capital, measured in a broad sense. The significance of this last causality is higher. Moreover, both relationships remain robust once the physical investment ratio is introduced into the model in order to test for robustness and to test the existence of complementarities between physical and human capital as stressed and analyzed in the economic literature.

Nevertheless, if we split the sample into two parts in order to consider the richest countries on one hand and the poorest on the other, our results lead to some different findings. Whereas human capital causes growth and vice versa in the poorest sample, both relations lose significance once the investment rate is taken into account as a control variable. This means that there might be a link between human and physical capital which is worth explaining. This can be confirmed if we turn our attention to the richest sample. In this particular case, human capital does play a crucial role causing growth and its significance remains higher after control by investment. On the contrary, growth does not causing the human capital level in the richest.

This is an eloquent outcome that leads us to investigate the causation between human capital, investment and growth in greater depth. The next table summarises the Granger-causality test results between physical investment and human capital on one hand, and between investment and growth on the other.

15 Kyriacou (1992, 2).

Table 6: Causality test between human capital investment and growth:

Summary index of human capital1	INV→HC	HC→INV	INV→GDPpc)	∆GDPpc→INV
Whole sample	F=16.825 Chi-squred=33.650	F=16.213 Chi-qured=32.427	F=57.391 Ch-qured=114.783	F=1.704 Ch-qured=3.409
The richest	F=17.705 Chi-squred=35.410	F=31.321 Chi-qured=62.642	F=16.026 Ch-qured=32.053	F=0.697 Ch-qured=1.394
The poorest	F=54.660 Chi-squred=109.321	F=1.227 Chi-qured=2.455	F=25.034 Ch-qured=50.068	F=1.890 Ch-qured=3.781

As we can see for the whole sample, the investment in physical capital causes the investment in human capital. It is also clear that investment in physical capital is a significant cause of growth while, on the other hand, it is not clear that growth leads to investment.

The inverse relationship is maintained, in other words human capital leads to investment, due mainly to the double causation between these two variables in the sample of rich countries. In this group investment in physical capital leads to investment in human capital but the opposite relationship, from human to physical capital, is more significant. This causation, then, operates in both directions and, although it is stronger moving from human capital to physical capital, it is possible to conclude that neither variable precedes the other and rather that both operate simultaneously. We also observe that, in the case of this sample of rich countries, investment in physical capital causes growth but that growth in itself does not cause investment.

On the contrary, in the case of the sample of poor countries investment leads to human capital with this variable preceding investment in human capital. There is no evidence of the inverse relationship while it can be observed that investment leads to growth. So, in the case of the sample of poor countries human capital affects growth via investment. Initial investment in these countries will subsequently lead to increased levels of human capital and economic growth.

This same relationship has been found in some empirical studies justifying the limited impact of human capital on the estimation growth regressions that control for the accumulation of physical capital. Barro (1991), for instance, argues that a significant part of the effect of human capital is channelled through an increase in the investment rate for physical capital[16]. Ranis, Steward and Ramirez (2000), who show in a cross-country regression that the connection between an improved level of human development[17] and increases in per capita growth is not automatic, reached the same conclusion. In their opinion the creation of a larger pool of educated people is not sufficient; there must also be opportunities for them to be productively employed and in this sense, investment rates, technology choices and the overall policy setting are the crucial elements[18]. In the particular case of Latin America, Astorga (2010), analyzing the six largest economies over 105 years (1900-2004) reaches the conclusion that physical and human capital prove to be key determinants of GDP per head growth.

De Gregorio (1992) says that the accumulation of physical and human capital have been key drivers of long-term growth in the

16 See, for example, Tamura (2002), Sianesi and van Reenen (2003) and Kruger and Lindahl (2001) among others.
17 The authors consider the human development concept of a country as consisting of the health and education of its people, a measure similar to that used in this paper to conform the concept of human capital.
18 Ranis, Stewart and Ramirez (2000, 203).

region and adds that the failure of the literacy rate to show a significant coefficient in some cases may be due to its colinearity with physical investment[19].

In other words, the basic idea of this paper, in line with other studies, is that investment in physical capital represents a fundamental link between human capital and economic growth. In the case of the poor countries investment in physical capital precedes that in human capital while, in the case of the rich countries the two variables act simultaneously, although it is also true that for this sample causation from human to physical capital is stronger.

This is also in line with the argument put forward by Goldin and Katz (1998), according to which the relationship between the two types of capital depends on the development level. Galor y Moav (2004), who developed a growth theory that captures the replacement of physical capital accumulation by human capital accumulation as a prime engine of growth during the process of development, reached the same conclusion. Their research demonstrated that in the early stages of development physical capital accumulation is the prime engine of economic growth, but in the later stages of the transition to modern growth, human capital emerges as the main explanatory variable. There is, then, a process of replacement of physical capital by human capital in the transition to modern growth. The same explanation can be applied in the case of the Latin American countries due to the dissimilar stage of development of the sample of the richest and the poorest countries in the region.

7.- CONCLUSIONS:

The importance of human capital as a factor behind the economic growth of countries is clear, especially in the case of countries in early stages of development. At a theoretical level its relevance as an explanatory factor is clear whether a neoclassical or an endogenous approach is employed. Problems arise, however, at an empirical level when it becomes necessary to measure the concept of human capital accurately. Different factors related with primary and secondary education are normally taken into account as proxies and the results obtained often do not match the theory.

Since Becker's pioneering studies (1962) it has commonly been accepted that this concept of human capital consists of a set of factors which are not normally considered in applied studies. Thus factors such as professional experience, health and fertility and mortality rates also reflect an economy's level of human capital.

An additional problem arises in empirical analyses which, in line with theoretical precepts, normally consider human capital as an explanatory variable without considering the possibility that this variable, as it is related with growth, may experience a double causation.

This paper has attempted to tackle this dual problem with an approach using a sample of 18 Latin American countries for the period 1950-2000. This group of countries has not been the object of many studies and its heterogeneous nature allows us to make some interesting observations.

The paper includes the creation of a broader index of human capital than employed in other studies and includes aspects of human capital not previously taken into consideration. Using this index the causation analysis carried out confirms that, while the relation moves in the direction from economic growth to human capital, there is also a bidirectional relationship between the two variables. This double causation

19 De Gregorio (1992,76).

is robust as it is maintained when the investment rate for physical capital is included in the model.

Nevertheless, this general situation is less clear when the rich and poor countries are considered separately. The inclusion of the investment rate shows the endogeneity between physical and human capital. It appears, then, that investment in physical capital is a fundamental link between growth and human capital which precedes human capital in the region's poor countries and operates simultaneously with human capital in the richer nations in order to explain per capita growth.

APPENDIX:

List of countries in the analysis:

1.-Argentina; 2.-Bolivia; 3.-Brazil; 4.-Chile; 5.-Colombia; 6.-Costa Rica, 7.-The Dominican Republic; 8.- Ecuador; 9.- Guatemala; 10.-Honduras; 11.-Haiti; 12.-Mexico; 13.- Nicaragua; 14.- Panama; 15.- Peru; 16.- El Salvador; 17.- Uruguay; 18.- Venezuela.

The richest sub-sample: Argentina, Brazil, Chile, Colombia, Mexico, Uruguay, Venezuela.

The poorest sub-sample: Bolivia, Costa Rica, The Dominican Republic, Ecuador, Guatemala, Honduras, Haiti, Nicaragua, Panama, Peru, El Salvador.

Variables included in the model and its sources:

Gross domestic product per head: PWT 6.1

Investment rate: PWT 6.1

Active population rate of growth: Oxlad data base.

Primary and secondary enrolment: CEPAL 1990 and 2001 and Oxlad data base.

Number of inhabitants per doctor: CEPAL 1990 and 2001.

Infant mortality rate: CEPAL 1990 and 2001

Dependency rate: CEPAL 1990 and 2001

Life expectancy: CEPAL 1990 and 2000

Public expenditure: PWT 6.1

OPEN: Imports and exports in reference to GDP: PWT6.1.

Table A.1: Correlation matrix:

	MORI	SAN	PRIM	SEC	ESPV	DEP
MORINF						
NF	1.000	1.000				
SAN	0.500	-0.469	1.000			
PRIM	-0.593	-0.541	0.809	1.000		
SEC	-0.638	-0.591	0.705	0.757	1.000	
ESPV	-0.949	0.334	-0.407	-0.617	-0.569	1.000
DEP	0.507					

Table A.2: Communalities

Variable	Initial	Extraction
MORINF	1.000	0.751
SAN	1.000	0.469
PRIM	1.000	0.674
SEC	1.000	0.798
ESPV	1.000	0.888
DEP	1.000	0.470

Table A.3: Total variance explained

Factor	Initial auto values		
	Total	% from the variance	% accumulated
1	4.050	67.497	67.497
2	0.677	11.289	78.785
3	0.560	9.326	88.112
4	0.536	8.935	97.047
5	0.146	2.428	99.475
6	3.150E-02	0.525	100.000

Table A.4: Factor matrix:

Variable	Factor 1	Factor 2
MORINF	-0.866	0.109
SAN	-0.685	-7.856E-02
PRIM	0.821	-0.517
SEC	0.893	-2.129E-02
ESPV	0.942	0.625
DEP	-0.685	3.868E-02

DUM: dummy which takes the value of 1 for the 1980s and 0 otherwise.

Terms of trade: Oxlad data base

Principal component analysis for the construction of the human capital index.

We have obtained the weight of each variable from Factor 1. –2.051 for MORINF, -1.621 for SAN, 1.944 for PRIM, 2.116 for SEC, 2.233 for ESPV and –1.621 for DEP

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(Footnotes)

1 The investment rate is also a stationary variable with values of -5.360, 56.527 and 53.154 for the Levin, Lin & Chu test, the ADF Fisher Chi-square and the PP Fisher Chi-square respectively.

2 The critical values for F(2, 42)=3.180 and for Chi-square(2)=5.991. When the model considers the investment rate as a control variable, the critical values are F(2.40)=3.232 and for Chi-square(2)=5.991.

3 The critical values for F(2.13)=3.806 and for Chi-square(2)=5.991. When the model considers the investment rate as a control variable, the critical values are F(2.11)=3.982 and for Chi-square(2)=5.991.

4 The critical values for this sample are: F(2.21)=3.467 and Chi-square(2)=5.991. When the model considers the investment rate as a control variable, the critical values are F(2.19)=3.522 and for Chi-square(2)=5.991.

5 The critical values are the same as those in Table 5.